2.094

FINITE ELEMENT ANALYSIS OF SOLIDS AND FLUIDS Spring 2008

Quiz #2

05/08/2008

Problem 1 (10 points)

A computer program is used to perform a plane strain analysis. A total Lagrangian formulation is employed with the given elastic material law. Consider the 4-node element shown at time "t". For this time:

- a) Calculate the deformation gradient.
- b) Calculate the second Piola-Kirchhoff stresses.

c) Give the equation to calculate the Cauchy stresses. Do not actually do the arithmetic.

$${}_{0}^{t}\underline{S} = E\begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1/2 \end{bmatrix} {}_{0}^{t}\underline{\varepsilon};$$
 Poisson's ratio = 0



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Problem 2 (10 points)

A two-dimensional steady-state planar fluid flow analysis solving the Navier-Stokes equations assuming incompressible, very low Reynolds number flow is to be performed. The governing equations in the principle of virtual velocities are:

$$\int_{V} \overline{v}_{i} \left(\rho v_{i,j} v_{j} \right) dV + \int_{V} \overline{e}_{ij} \tau_{ij} dV = \Re$$
$$\int_{V} \overline{p} v_{i,i} dV = 0$$
$$\tau_{ij} = -p \delta_{ij} + \mu \left(v_{i,j} + v_{j,i} \right) = -p \delta_{ij} + 2\mu e_{ij}$$

Assume that the Reynolds number is so small that the first term (the convection term) on the left-hand side of the first equation can be neglected (Stokes flow is assumed).

The 9/3 velocity/pressure element is to be used for the solution.

- a) Evaluate the finite element matrix entry K(1,1) corresponding to the nodal velocity v_1^1 shown.
- b) Evaluate the finite element matrix entry K(1, 21).

In each case, (a) and (b), give all integrals but do not perform any integration.



where v_j^i is the velocity at node *i* into direction *j*.

c) State briefly whether the 9/3 element is a suitable element for the analysis; give your reason.



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